

LM1872 Radio Control Receiver/Decoder

General Description

The LM1872 is a complete RF receiver/decoder for radio control applications. The device is well suited for use at either 27 MHz, 49 MHz or 72 MHz in controlling various toys or hobby craft such as cars, boats, tanks, trucks, robots, planes, and trains. The crystal controlled superhet design offers both good sensitivity and selectivity. When operated in conjunction with the companion transmitter, LM1871, it provides four independent information channels. Two of these channels are analog pulse width modulated (PWM) types, while the other two are simple ON/OFF digital channels with 100 mA drive capability. Either channel type can be converted to the other form through simple external circuitry such that up to 4 analog or up to 4 digital channels could be created. Few external parts are required to complement the self-contained device which includes local oscillator, mixer, IF detector, AGC, sync output drivers, and all decoder logic on-chip.

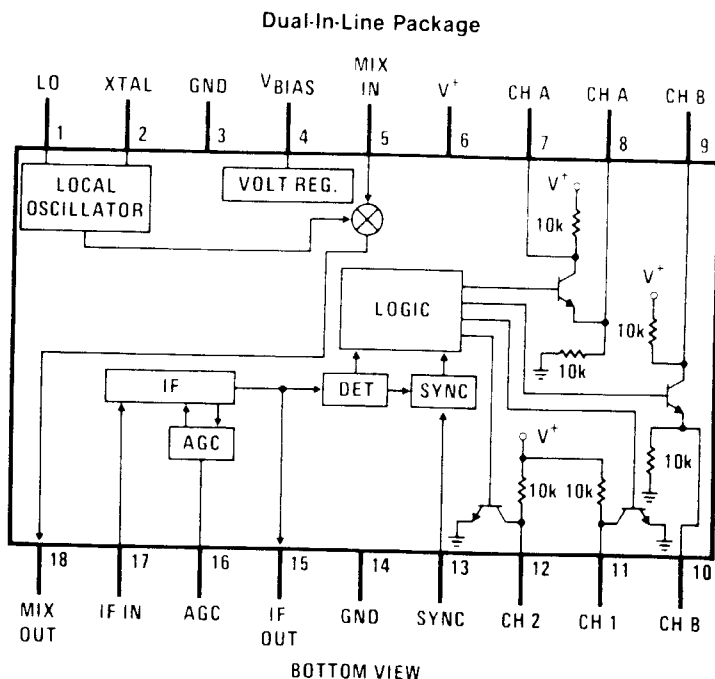
Features

- Four independent information channels; two analog and two digital
- Completely self-contained
- Minimum of external parts
- Operation from 50 kilohertz to 72 MHz
- Highly selective and sensitive superhet design
- Operates from four 1.5V cells
- Excellent supply noise rejection
- 100 mA digital output drivers
- Crystal controlled
- Interfaces directly with standard hobby servos

Applications

- Toys and hobby craft
- Energy saving, remotely switched lighting systems
- Burglar alarms
- Industrial and consumer remote data links
- IR data links
- Remote slide projector control

Circuit Block and Connection Diagram



Absolute Maximum Ratings

Supply Voltage	7V
Package Dissipation (Note 2)	1000 mW
Voltage @ Pin 7, 8, 9, 10, 11 or 12	V ⁺
Operating Temperature Range	- 25 °C to + 85 °C
Storage Temperature Range	- 65 °C to + 150 °C
Lead Temperature (Soldering, 10 seconds)	300 °C

DC Electrical Characteristics

V⁺ = 6V, T_A = 25 °C, Test Circuit of Figure 1, f_{L0} = 49.890 MHz, f_{IF} = 455 kHz unless otherwise specified.

Parameter	Conditions	Min	Typ	Max	Units
Supply Voltage	Functional for V _{IN} = 100 μV	2.5	6	7	V
Supply Current	CH A & B Off	9	13	18	mA
	CH A & B On		27		mA
V _{BIAS}	@ Pin 4	1.85	2.1	2.35	V
Sync Timer Threshold	@ Pin 13. Going from Low to High Voltage	V ⁺ /2 - 0.4	V ⁺ /2	V ⁺ /2 + 0.3	V
Digital Channels A and B					
Saturation Voltage	@ Pins 7 & 9. R _L = 100Ω		0.4	0.7	V
Saturation Resistance	@ Pins 7 & 9		7		Ω
Source Current	@ Pins 8 & 10. V _{Pin 8 & Pin 10} ≤ 1V	100			mA
Collector Pull-Up Resistance	Pin 7 & Pin 9 to V ⁺	5	10	20	kΩ
Emitter Pull-Down Resistance	Pin 8 & Pin 10 to GND	5	10	20	kΩ
Analog Channels 1 and 2					
Saturation Voltage	@ Pins 11 & 12. R _L = 2 kΩ		0.45	0.7	V
Saturation Resistance	@ Pins 11 & 12		160		Ω
Collector Pull-up Resistance	Pin 11 & Pin 12 to V ⁺	5	10	20	kΩ

AC Electrical Characteristics

Parameter	Conditions	Min	Typ	Max	Units
RF Sensitivity	For "Solid" Decoded Outputs (Note 1)		22	39	μV
RF Sensitivity	Circuit of Figure 5 @ 49 MHz with Antenna Simulation Network of Figure 6		12		μV
Voltage Gain	Pin 5 to Pin 15		58		dB
PSRR of RF Sensitivity	3V ≤ V ⁺ ≤ 6V		-1		%Δ/V
BW	3 dB Down @ Pin 15		3.2		kHz
Noise	Referred to Input, Pin 5, V _{IN} = 0		0.35		μVrms
	Referred to IF, Pin 15, V _{IN} = 0		0.28		mVrms
AGC Threshold	Onset of AGC Relative to RF Input, V _{IN} , @ Pin 5		88		μV
	Relative to IF Output @ Pin 15	V ⁺ + 0.07	V ⁺ + 0.100	V ⁺ + 0.13	V
Mixer Conversion Transconductance	From Pin 5 to Pin 18 @ 1 MHz	2.9	4.0	6.9	mmhos
	@ 27 MHz		3.7		mmhos
	@ 49 MHz		3.5		mmhos
Mixer Input Impedance	Pin 5 to Pin 4 @ 49 MHz (See Curves)	r	20 kΩ + 5 pF		

AC Electrical Characteristics (Continued)

Parameter	Conditions	Min	Typ	Max	Units
Mixer Output Impedance	Pin 18 to GND		250		k Ω
IF Transconductance	Pin 17 to Pin 15 (AGC Off) @ 455 kHz	2.6	4.1	5.6	mmhos
IF Input Impedance	Pin 17 to GND		5500		Ω
IF Output Impedance	Pin 15 to GND (AGC Off)		800		k Ω
	(AGC On)		2		M Ω
IF Carrier Level	@ Pin 15, $V_{IN} = 100 \mu V$ (AGC On)		70		mVrms
Detector Threshold	Relative to RF Input, V_{IN} , @ Pin 5		20		μV
Analog Pulse Width Accuracy	Relative to IF Output @ Pin 15 Ratio of Received Pulse Width @ Pins 11 & 12 to Transmitted Pulse Width @ Pin 5 for $V_{IN} = 100 \mu V$	$V^+ + 0.015$ 0.95	$V^+ + 0.025$ 1.0	$V^+ + 0.040$ 1.05	V ms/ms

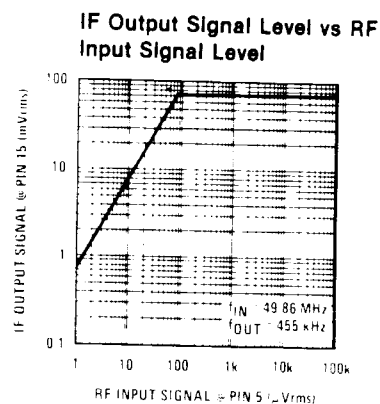
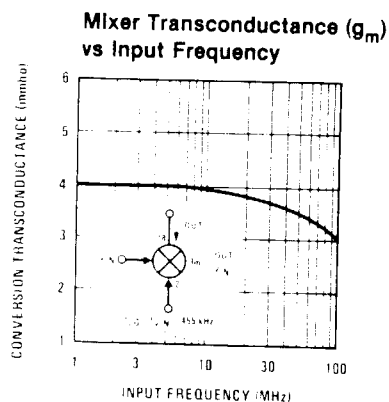
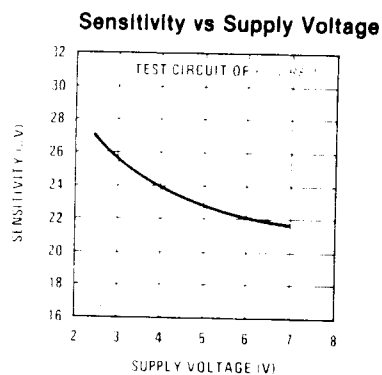
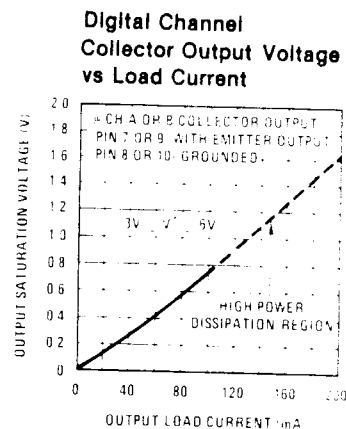
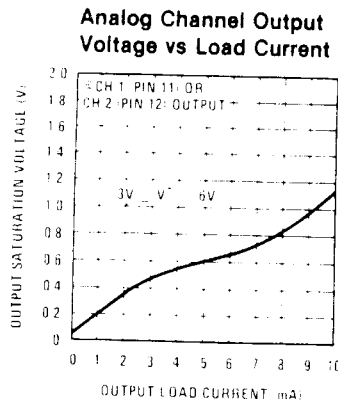
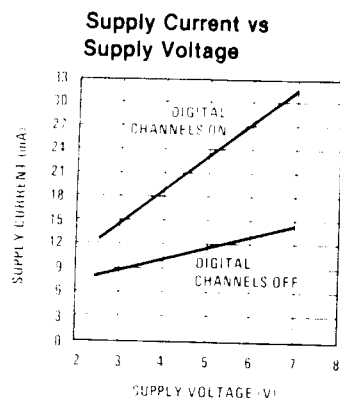
Note 1: The criteria for the outputs to be considered "solid" are as follows:

DIGITAL: In order to check the decoding section, four RF frames are inputted in sequence with the proper codes to exercise all four possible logical output combinations at pins 7 and 9. For each frame the proper output logic state must exist.

ANALOG: Each analog pulse width (measured at pins 11 & 12) in any of the above four successive frames must not vary more than $\pm 5\%$ from the pulse widths obtained for $V_{IN} = 100 \mu V$.

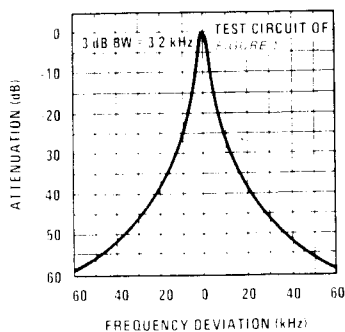
Note 2: For operation in ambient temperatures above $25^\circ C$, the device must be derated based on a $150^\circ C$ maximum junction temperature and a package thermal resistance of $120^\circ C/W$, junction to ambient.

Typical Performance Characteristics

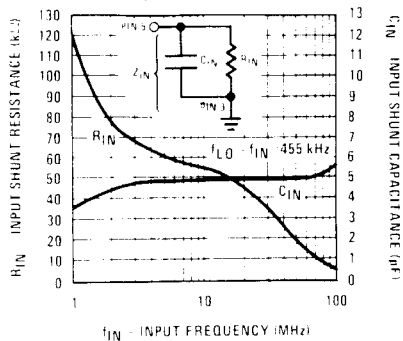


Typical Performance Characteristics (Continued)

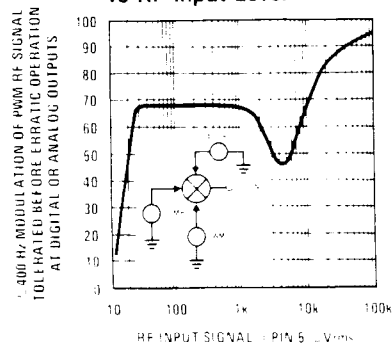
IF Bandpass Response



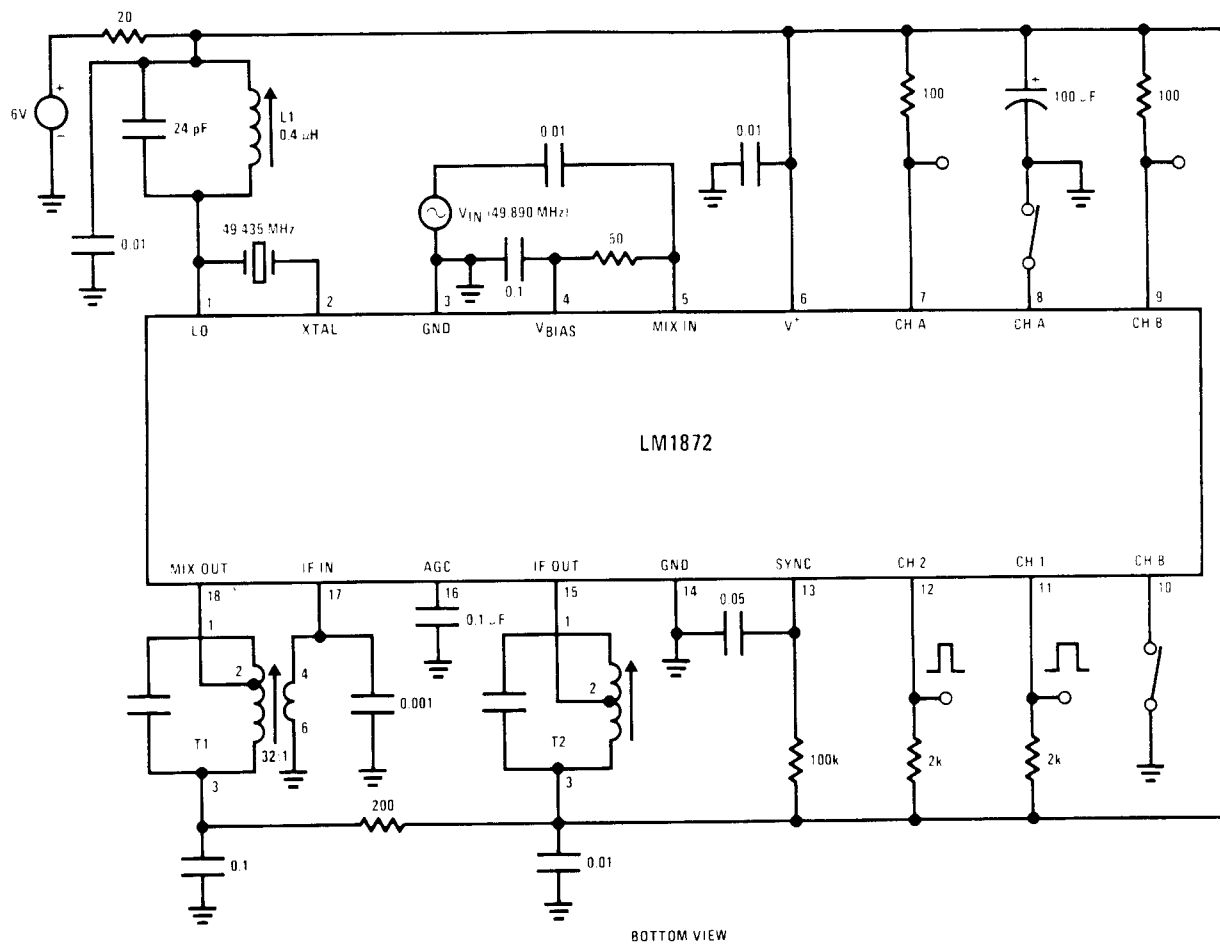
Equivalent Mixer Input Shunt Resistance and Capacitance vs Frequency



Receiver AM Rejection vs RF Input Level



Test Circuit



L1 = Toko* 10k type (KEN-4028 DZ); 6T
T1 = Toko* 10 EZC type (RMC 202313 NO); $Q_u = 110$
Pin 1-2, 131T; pin 2-3, 33T
Pin 1-3, 164T; pin 4-6, 5T

T2 = Toko* 10 EZC type (RMC 402503 NO); $Q_u = 110$
Pin 1-2, 98T; pin 2-3, 66T
Pin 1-3, 164T; pin 4-6, 8T

* Toko America, Inc.
5520 West Touhy Ave.
Skokie, Ill. 60077
(312)677-3640 Tlx: 72-4372

FIGURE 1. Test Circuit

Circuit Description

The following discussion is best understood by referring to Figures 2, 3, 4, and 5.

SYSTEM ENCODING AND DECODING SCHEME

For the transfer of analog information, the LM1871/LM1872 system uses conventional pulse width modulation (PWM). In applying this technique, the RF carrier is interrupted for short fixed intervals (t_M in Figure 2) with each interval followed by variable width pulses (t_{CH}) so as to define multiple variable time spans ($t_M + t_{CH}$) occurring in serial fashion. Synchronization is accomplished by allowing one of the transmitted variable pulse widths (t_{SYNC}) to exceed the duration (t_{SYNC}) of a receiver-based timer, thus allowing the receiver to recognize this pulse for synchronization purposes. Taken in sequence, this collection of pulses constitutes a single frame period (t_F).

The LM1871 transmitter is equipped to transmit up to six channels which the companion LM1872 receiver uses to derive 2 analog and 2 digital channels. The receiver decodes the demodulated RF waveform from the transmitter by negative edge triggering a cascade of three binary dividers called the A, B, and C toggle flip-flops (Figure 4). By "examining" all three flip-flop outputs simultaneously, up to 6 unique channel time intervals could be identified and recovered. Only the first two channels are actually decoded however and outputted by the receiver, the rest being used for identification of two digital (ON/OFF) channels. In passing digital information, a pulse count modulation scheme is used whereby different quantities of channel pulses are transmitted by varying the number of fixed width channels following the two variable width analog channels 1 and 2 (see Figure 3).

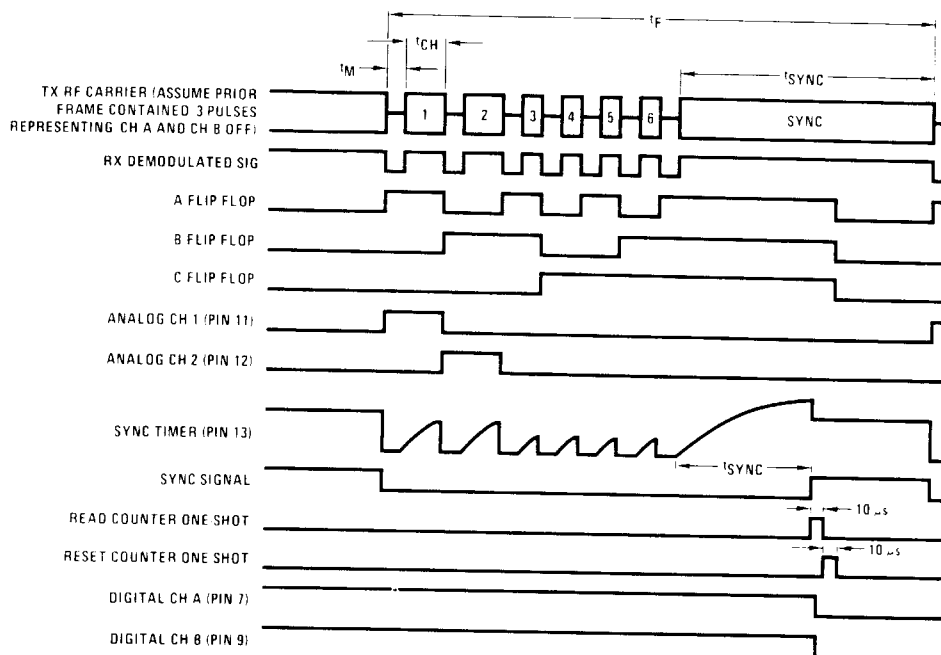


FIGURE 2. RX Timing Waveforms

LM1871 TX			LM1872 RX		
PIN CONDITIONS		TRANSMITTED WAVEFORM	BINARY PULSE COUNT	DIGITAL OUTPUTS	
PIN 5 (CH A)	PIN 8 (CH B)			CH A	CH B
OPEN	OPEN		100	OFF	OFF
GND	OPEN		101	ON	OFF
OPEN	GND		110	OFF	ON
GND	GND		111	ON	ON

FIGURE 3. Digital Channel Encoding and Decoding via Pulse Count Modulation

Circuit Description (Continued)

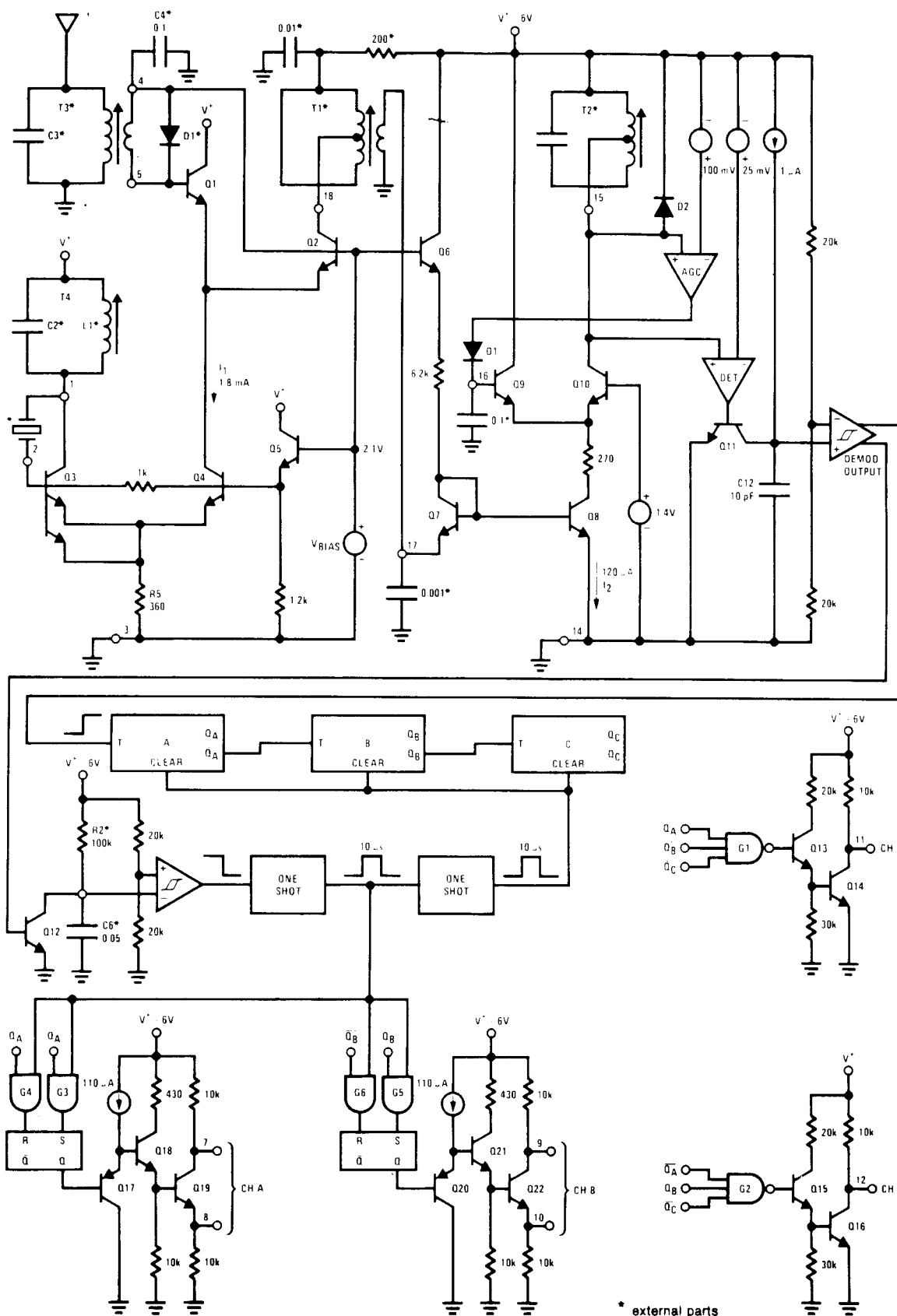


FIGURE 4. Simplified Schematic Diagram